and what each one should refrain from doing, the whole execution of the work decided upon being left completely in the hands of the regular authorities. We see no reason why this should be "irksome" to the heads of the departments. We also feel that Major Powell assigns undue importance to the influence of the single military officer proposed by the Academy as one of the nine members of the Commission. It is not so clear to us, as it seems to be to him, that one such officer could leaven the whole lump of the Commission with ideas of military discipline unsuitable to the conduct of a scientific bureau.

But however favourably we may view the plan of this Commission, we must hold that the consolidation of the bureaus under a single head, or in a single department, would give far more assurance of efficiency. Especially is this the case with the two national surveys. Their work now covers the same fields, and their mutual interdependence is such that they should work under a common plan. The Geological Survey requires for its proper execution certain geodetic and astronomical work, the execution of which is not within the proper province of the geologist. It is absolutelynecessary that this geodetic and astronomical work should be so planned and executed as to meet the wants of the Geological Survey, and at the same time it is the proper function of the geodetic survey. We are informed by Major Powell that he makes use of all the coast-survey results so far as they are available, but he does not indicate what fraction of his labour is thus saved; and it goes without saying that he has no authority, directly or indirectly, to require that the coast and geodetic survey shall do anything which he may want done.

Among the suggestions made by Major Powell was one that all the scientific bureaus should be placed under the general direction of the regents of the Smithsonian Institution. This does not appear to have been considered practicable, and was not further urged by the director himself. One of the possible plans is to place all these bureaus under the interior department. The principal objection to this course is that that department is already overloaded with work, so that its head could not give the proper consideration to the subject. Yet this is the simplest course, and would certainly be an improvement on the present state of things. The more effective course would be to form a separate department of science and public works. To this there seems to be no positive and serious obstacle except the difficulty of getting any measure of the sort enacted into a law. The question whether the head of the department should be a scientific expert or a public administrator is an ulterior one, which need not be discussed at present. In the latter case the question of its being regarded as a cabinet office would arise. There will be little hesitation in deciding this question in the negative.

THE LICK OBSERVATORY[1]

THE Lick Observatory, in its present condition on the summit of Mount Hamilton, California, is so nearly completed, with the exception of the great telescope, that the institution may now be sketched to advantage in its permanent form. In an early issue of *Science*, therefore, this enterprise will be traced through its various stages, from the inception onward. Astronomers have been slow to avail themselves of the great advantages of mountain elevation and isolation in the prosecution of astronomical research, partly because of the pecuniary outlay attending the necessary expeditions, but chiefly because some of the earlier expeditions to mountain summits were not attended with results of especial importance, and, on good theoretical grounds, the meteorological conditions of such stations appeared likely to be so unfavourable as to counterbalance fully the advantages to be derived from mere elevation. And besides, the evidence derived from the two most famous expeditions—that of Prof. C. Piazzi Smythe to the Peak of Teneriffe and of Mr. William Lassell to Malta—was so contradictory in character as to afford very good ground for abandoning the hope of immediate advantage to astronomy from superior elevations.

It is not possible to say how far Mr. James Lick was acquainted with these endeavours of scientific men; nor need the immediate circumstances or events which impelled him to his extraordinary astronomical bequest be considered here. Prof. Newcomb points out the fact that his movement followed close upon the completion of the great Washington telescope in 1873, then the largest in existence. Had Mr. Lick known the opinions of the best astronomers on the subject of mountain observatories, and the likelihood of securing, on elevated and isolated peaks, results at all commensurate with the trouble and expense of occupying such stations, he would have found very little to encourage the project. In this case, however, as very often before, a little experience has proved to be worth more than an indefinite amount of scientific theorising. It has been said that the scheme of building "a powerful telescope, superior to and more powerful than any yet made," was the nearest of all to the heart of Mr. Lick: there is abundant evidence that this is true; and it may be also true that he regarded the Observatory as an appendage of the telescope. But the course of subsequent events has proved it a matter for sincere gratulation in astronomical circles that he ever regarded either the Observatory or the telescope at all; for, had not the prospective researches with the great telescope arrested his attention, there is very little reason for believing that, in so far as he was concerned, astronomical science would ever have been in a position to reap benefit from the splendidly equipped Observatory which already exists on the summit of Mount Hamilton.

That Mr. Lick was bound, heart and soul, in the project, not only of a great telescope, but of the best possible location for it, is evident from the fact that, when nearing his eightieth year, and although oppressed with physical infirmity, he resolutely undertook a waggon journey of some forty miles or more, reclining on a mattress, all for the sake of investigating a proposed mountain site in person. His solicitous concern for the enterprise was very marked. Those who knew him best say that, if his practical knowledge of astronomy had been greater, he would have given every penny of his vast fortune for the great telescope, and the Observatory and its endowment. He would have recognised, too, the great improbability of such an institution being completed within a period of a few short years, and would thus have been led to provide for the reasonable use of the instrumental equipment as fast as it was put in place on the mountain. The failure to make such provision constitutes the chief point of unfavourable criticism on the part of astronomers, and is in many respects unfortunate; but sundry advantages also have arisen from it, which may be recognised with more profit, particularly as this condition of things must remain unalterable until the great telescope is completed, and the entire institution comes under the administration of the University of California, in full accord with the terms of Mr. Lick's bequest.

Five years ago no one could have anticipated that the year 1886 must pass with the great telescope still unfinished. It is worthy of note, however, that, while the delay in obtaining the necessary glass for the objective has proved so great an embarrassment to the work of the opticians, it has not as yet sensibly impeded the progress of the construction of the Observatory itself. To this fact we alluded at p. 377 of the current volume of *Science*, stating as well the very reasonable grounds for the belief that the plans of the Lick trustees, in so far as they pertain to the construction of the great telescope

[1] From *Science*.

and the conjoint Observatory, will be completely executed at the close of the year 1887. With its unparalleled instrumental equipment, and an unusual endowment for the prosecution of astronomical research; located where the sky is cloudless most of the year, and at such an elevation as to be above the clouds a great part of the remainder; and situate in a region, too, where the steadiness of the air permits astronomical measurement of the highest precision to proceed uninterruptedly throughout the entire night for months at a time,—the Lick Observatory is destined, under prudent management, to take its place at once in the foremost rank; and, although it is the first established mountain observatory, it may well expect to hold its own in the emulation of similar institutions which may subsequently be inaugurated at greater elevations.

TWILIGHT[1]

THIS essay, an extract from a more comprehensive work on the problem of twilight, which the author hopes to conclude in the course of this year, and embodying a lecture recently delivered by him both in Hamburg and Leipzig, describes the phenomena of twilight in general and of the remarkable sky-glows of the winter of 1883 in particular, with clearness, fullness, and exactness, and explains the physical causes of these phenomena from a special and mature study of that universally interesting field of observation, by numerous highly pertinent and illustrative experiments, and altogether in a manner which should bring home, even to the unscientific reader, a new sense and a new intelligence of the painting offered anew every morning and evening to the study and delight of man universally.

After relating and taking measure of the stupendous outburst of Krakatoa and the brilliant glows involving nearly the whole earth for a long period after that event, and comparing these two consecutive phenomena with the analogous phenomena of the outburst of "Graham Island" in 1831, followed by brilliant twilights and peculiar blue and violet sun colours, attracting the admiration, in particular, of Italy, France, and Germany, the book addresses itself to the task of investigating the physical laws concatening these two apparently heterogeneous phenomena, and why all volcanic outbursts are not attended by the same wonderful optic displays. While each particle of dust, smoke, or fog causes a bending or diffraction of the light, a collective effect, comprehending a brilliant development of colours, is produced only when all the particles of matter are of equal size and are distributed uniformly in space—a condition not even most remotely fulfilled in the case of ordinary smoke and fog. Diffraction includes the lateral dispersion of the light, which is all the more efficient the nearer the edges lie to each other, and therefore the smaller the particles are, and also the "interference" of like-coloured rays of light. When a red light falls, for example, on a fine glass thread or a diamond stroke scratched into glass, the shadow will consist not of one thin black line, but of a whole system of parallel stripes alternately dark and brilliant, *i.e.* black and red. When, again, a white light falls on the diamond stroke, the reflection shows a system of parallel stripes glowing in all the colours of the rainbow. In the case of a single line the development of colours is indeed so small as to be scarcely perceptible, but with many thousand lines of exactly the same breadth, and situated at exactly the same distance from one another, the reflex image is such that, taken up on a white screen, it is visible at great distances. Perfectly corresponding is the case with granules of dust. The shadow of a single granule of dust in red light consists of a system of concentric rings, alternately dark and redly luminous, which are all the broader the smaller is the granule. In white light, on the other hand, the shadow of the granule consists of alternately dark and bright rainbow coloured rings. If the dust granules are all of the same size, then will the like-coloured rings pretty nearly coincide, and, in the case of a sufficiently large number of granules, the reflex image will be composed of coloured rings of great luminousness. If, on the other hand, the dust-granules are of different size, then will all the different colours coincide, and, according to a well-known optic law, the image will be colourless. The image of a dust-cloud may, therefore, be rich in colours, poor in colours, or colourless, according as the particles of dust of which it is composed are of the same or of different size.

The experiments of Coulier and Mascart, extended by Aitkin, have demonstrated that in a perfectly moist air, no formation of fog is possible, however much the temperature is lowered, so long as the air is absolutely free of dust; and that the more air, sufficiently moist, is charged with such foreign particles, the more intense is the formation of fog under a sufficient lowering of the temperature or pressure of the air. Let filtered and completely moist air in a glass ball have its pressure diminished, then will only a few particles of fog reveal themselves to the most careful inspection, even under the powerful light of an electric lamp—particles of fog which, moreover, yield not the slightest coloured image. Admit now into this filtered air a few cubic millimetres of ordinary house air, then will a very fine, silvery, transparent fog at once form itself, of such slight density that even in the case of a considerable area of it the transparency of the atmosphere would be but very little affected. At the first moment of its formation let a reflected image of the sun, or the reflected light of an electric lamp, be viewed through it: the image will be seen surrounded by an intensely luminous blue or greenish light, with a broad, reddish ring, the colouring of which may range through all stages from brilliant purple red to the most delicate pale pink.

The phenomena of colour produced and explained by experiments of the above description are made to serve as the key to the more extensive but essentially identical phenomena composing the total process of twilight, which is distributed, like a spectacular play, into three acts with a prelude, and sometimes, though comparatively seldom, an afterlude—parts which, however, are not strictly distinguished in time, but occur to some extent simultaneously and overlap each other; as also to the comparatively unimportant deviations—apart from the intensity of colouring—from the normal course, which obtained in the remarkable sky-glows that arrested universal attention throughout the fall and winter of 1883.

[1] "Die Dämmerungserscheinungen im Jahre 1883 und ihre physikalische Erklärung." Von J. Kiessling, Professor am Johanneum zu Hamburg. (Hamburg und Leipzig. 1885.)

HENRY MILNE-EDWARDS

HENRY MILNE-EDWARDS was born at Bruges in October, 1800. Having completed his elementary studies in Belgium he attended medical lectures in Paris, where he took his diploma in medicine in 1823. While he retained an interest in medical and surgical pursuits until late in life, and was a member of the Academy of Medicine, Paris, of the Medical Societies of London, Edinburgh, &c., his earliest passion seems to have been for the study of natural history, and he soon abandoned the practice of his profession and devoted himself to scientific researches among the lower forms of animal life.

During the years 1826 and 1828, in company with his friend and fellow-labourer Audouin, the assistant to Lamarck and Latreille, he made a careful study of the various invertebrates to be met with on the coasts at Granville, around the Isles at Chansey, and as far as Cape Frehel. A member of the French Academy was,